THE STRUCTURE OF THE EYE OF SCUTIGERA (CERMATIA) FORCEPS.

JOSEPHINE HEMENWAY.

GRENACHER ('80), in his article entitled "Ueber die Augen einiger Myriapoden," described the structure of the eye of Scutigera (Cermatia araneoidea). Briefly reviewed, his account is as follows:

Externally the eye of Scutigera has the appearance of a true facet eye, consisting of one hundred of these "facets." To each facet there corresponds an ommatidium. Each ommatidium consists of a central crystalline body, surrounded by three tiers of cells; the distal tier of pigment cells, the middle and proximal tiers of retinular cells secreting on their inner edges a narrow band, the rhabdom. The crystalline body is composed of very irregular segments. These segments may be either cells or cuticular structures. In the adult eye they cannot be regarded as cells, as nuclei are not found in them, although Grenacher admits that at some time in their existence they may have been cells, later becoming modified and losing their nuclei. The possibility of their being secretion products he does not admit, as he finds no cells to which their origin could be traced. There are six to eight or nine of these segments.

The retinular cells with their rhabdoms embrace the proximal two-thirds or three-fourths of the crystalline body, the posterior portion of the retinular cells reaching to the basal membrane. Of the three tiers of cells surrounding the crystalline body, the middle tier, or outer retinula, is made up of from nine to twelve cells; the proximal tier, or inner retinula, of three to four cells. Sections through the proximal layer show that at this level the rhabdom is made up of four parts. Toward the extreme proximal end of these proximal retinular cells only three with their rhabdoms are visible in cross-

sections, the fourth having been pushed out. The nuclei of the retinular cells lie in the distal portion. The pigmentation of the eye consists partly of the pigment granules in the retinular cells and partly in the separate pigment cells. Of the latter there are three distinct groups: (1) a circle of from eight to ten large flattened cells, the outer tier of my description around the outer part of the crystalline body; (2) long, spindle-shaped pigment cells situated between the ommatidia, extending to the inner cuticula; (3) a third group, the supplementary cells of my account, is found on the posterior part of the retinula, between the retinular cells.

Grenacher also mentions the pigmentation of the optic nerve and the "inner cuticula."

Adensamer ('93), in his studies on this eye (Scutigera coleoptrata), confirms and completes Grenacher's statements. He differs in certain points.

The cornea of each ommatidium Grenacher regarded as externally convex, although there were individual differences. These differences Adensamer regards as stages in the development of the cornea.

In the adult eye frequently there were found in the crystalline body large yellowish enclosures, which had the appearance of fat drops. These are not to be confused with the nuclei for which Grenacher looked. Of the segments he found from seven to nine.

But in an individual 5 cm. long Adensamer states that he found nuclei in the crystalline body; thus he feels justified in calling the segments "cells."

As to the nerve fibers he was more successful than Grenacher, in that he saw the connection of the fiber with the outer and inner row of retinular cells. This he proved by sections. Just under the basal membrane there is a nerve connected with a muscle, which is entirely distinct from the optic nerve. Adensamer believes that this was probably mistaken by Grenacher for the real optic nerve. The latter consists of a bundle formed of the separate nerve fibers meeting proximal to the basal membrane.

Speaking of the superficial resemblance of the eye of Scutigera to that of insects and crustaceans, and the actual differ-

ences between them, Adensamer suggests calling the eye of Scutigera a "pseudo-facet" eye. Rosenstadt ('96) discusses the question as to whether the eye of Scutigera can be regarded as a true facet eye, reviewing the arguments of Grenacher and Adensamer. He also suggests a way by which an eye, as that of Scutigera, could be developed from a true facet eye.

The following work was done in the Biological Laboratory of Bryn Mawr College, under the direction of Prof. T. H. Morgan, to whom I am greatly indebted for valuable suggestions and criticism.

The species studied was Scutigera (Cermatia) forceps.

For sectioning, the best results were obtained by hardening the fresh material in corrosive acetic for fifteen minutes, then running it up through the successive grades of alcohol.

The dense pigment obscured all details, therefore a depigmenting agent, as KOH, was used (*cf.* Parker, "The Eyes in Scorpions," '87). The preparations were stained with iron-haematoxylin.

As a maceration fluid, a modification[1] of Béla Haller's fluid was used. Material left in it for a year gave excellent results. The separate ommatidia fell apart, and by gently tapping the preparation the individual cells of each ommatidium could be isolated.

By this means I have been able to make out more definitely the structure of the different component cells than have the authors mentioned above, and in some respects have been able to add some points to their results.

The eye of Scutigera forceps is nearly triangular in shape. The corneal hypodermis is faceted, one ommatidium corresponding to each facet. Each eye is composed of about two hundred individual units or ommatidia.

Fig. 1 *A* shows[2] a single ommatidium, its proximal end bordering on the inner cuticula or basal membrane.

[1] Béla Haller's mixture modified: two parts glacial acetic acid; two parts water; one part glycerine.

[2] The figures are all camera drawings: Fig. 1 *A* and *B* were drawn with a No. 7 objective; Fig. 1 *C* and *D* were drawn with an oil immersion $\frac{1}{12}$; Fig. 2 *A*, *B*, *C*, *D*, *E*, *F* were drawn with an oil immersion $\frac{1}{12}$.

Surrounding each ommatidium are elongated pigment cells, extending the entire length of the ommatidium (Fig. 1 *B*). At both distal and proximal ends these pigment cells become expanded, the pigment granules collecting in the expanded portions. At the proximal end this gives the pigmented appearance of the basal membrane, spoken of by Grenacher.

There are sixteen to eighteen of these pigment cells belonging to an individual ommatidium. The nuclei are visible without reagents, but are more clearly shown by methyl green.

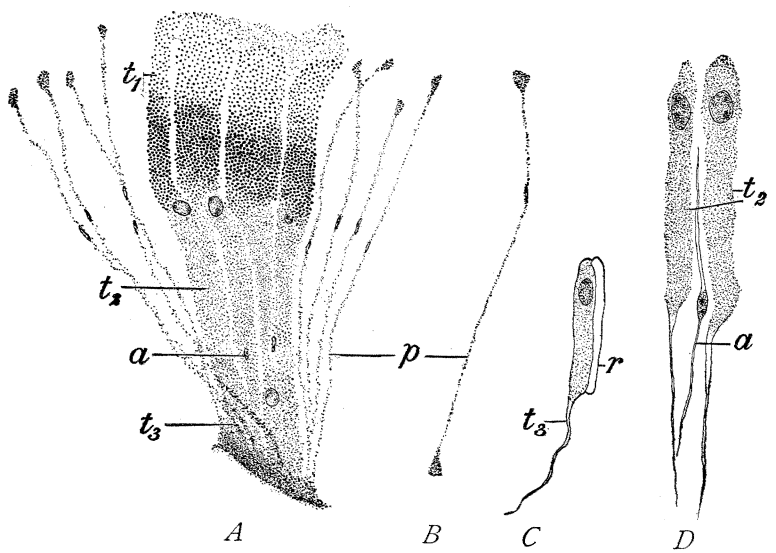

FIG. 1.

They are found at the same level as the nuclei of the middle tier of cells (Fig. 1 *A*). Each ommatidium consists of a clear, crystalline body, surrounded by three tiers of cells; the outer consisting of twelve (t_1), the middle of ten to twelve (t_2), and the inner tier of three to four cells, respectively (t_3).

The cells of the outer tier are large and flat and deeply pigmented at the proximal ends, the pigment granules being extremely large and round. The nuclei did not show in a macerated specimen, owing to the pigment.

The middle tier of cells are called by Grenacher the "outer retinular cells." They are longer and more narrow than the

cells of the outer tier, reddish in color, lacking the black pigment of the outer tier.

(Fig. 1) *D* t_2 shows two of these cells with the nuclei at the extreme distal portion. At the proximal end each cell is prolonged into an extremely fine "tail," which runs down between the cells of the inner tier and is continued through the basal membrane as a nerve fiber.

The cells of the inner tier have their proximal ends bordering upon the basal membrane. From the proximal ends fine processes continue through the basal membrane to form the nerve fibers. The cells are much broader than those of the middle tier.

Cross-sections through the different levels show the crystalline body occupying the central axis of the ommatidium, surrounded by a clear zone or rhabdom forming the inner parts of the cells of the ommatidium (Fig. 2 *B*, *r*). The clear zone is formed of the structures called by Grenacher the rhabdoms — a secretion product of the retinular cells. In macerated specimens these rhabdoms were visible upon the inner surface of each cell of the two proximal tiers (Fig. 1 *C*) and could be made to separate from the cell by tapping. The "tail," or nerve, is on the opposite side of the cell from the secreted portion. The secretions from the inner tier are thicker than from the middle tier, and in cross-sections appear roughly triangular in shape (Fig. 2 *F*). There were no nerve fibers observed for the outer tier, and it differs in this respect from the two inner tiers. In certain cases, after tapping, the outer cells unfolded, as it were, and spread out into a band. The distal ends are rounded, while the proximal ends are drawn down into a point which extends between the distal ends of the middle tier. Thus the nuclei of the middle tier are found between these points of the outer tier (Fig. 1 *A*).

The series of cross-sections (Fig. 2 *A–F*) are taken at the levels of the different nuclei.

I. The first section beneath the cornea is shown in Fig. 2 *A*. It represents the extreme distal portion of the ommatidia. A few large nuclei are found at this level, situated between the individual ommatidia.

II. The next figure (Fig. 2 *B*) is taken through the nuclei of the outer tier of cells, two sections intervening between *A* and *B*. These nuclei differ in shape from the round ones of the middle tier.

III. The next section (Fig. 2 *C*) shows two sets of nuclei, the larger ones (*n*) belonging to the middle tier of cells, the smaller (*p*) being the nuclei from the surrounding pigment cells (Fig. 1 *A*, *p*).

IV. Fig. 2 *D* shows a section through the nuclei of the middle tier of cells. This drawing is from the same section as *C*, but drawn at a lower level.

V. The following figure (*E*) is the fourth section after *D*. The round nuclei are from the clear cells or supplementary cells.

VI. Situated at about the same level as the nuclei shown in Fig. 2 *E*, but in the next section (Fig. 2 *F*), are the nuclei belonging to the inner tier of cells (Fig. 1 *A*, t_3).

The nuclei shown in Fig. 2 *E* belong to a group of cells lying between the two proximal tiers of cells. These cells are very different from any of the others found. They are colorless and contain no granules. Fig. 1 *D* shows two cells from the middle tier, between them one of these supplementary cells, in its natural position. The supplementary cells are extremely delicate, sending distally a fine process between the cells of the middle tier, and proximally between those of the inner tier. The nucleus is small and easily distinguished from that of a cell of the inner tier. The nuclei are found at the level of the distal ends of the inner cells. There are four supplementary cells.

The crystalline body is surrounded by the tiers of cells described above. It is composed of segments — "Grenacher's segments." These segments are cone-shaped. At the level of the nuclei of the inner tier (Fig. 2 *F*) these are not seen in cross-section, the rhabdoms, only, belonging to these cells being visible. In maceration preparations they often separate from each other at the proximal ends, while found joined at the larger distal ends.

According to Adensamer there are nuclei in these bodies

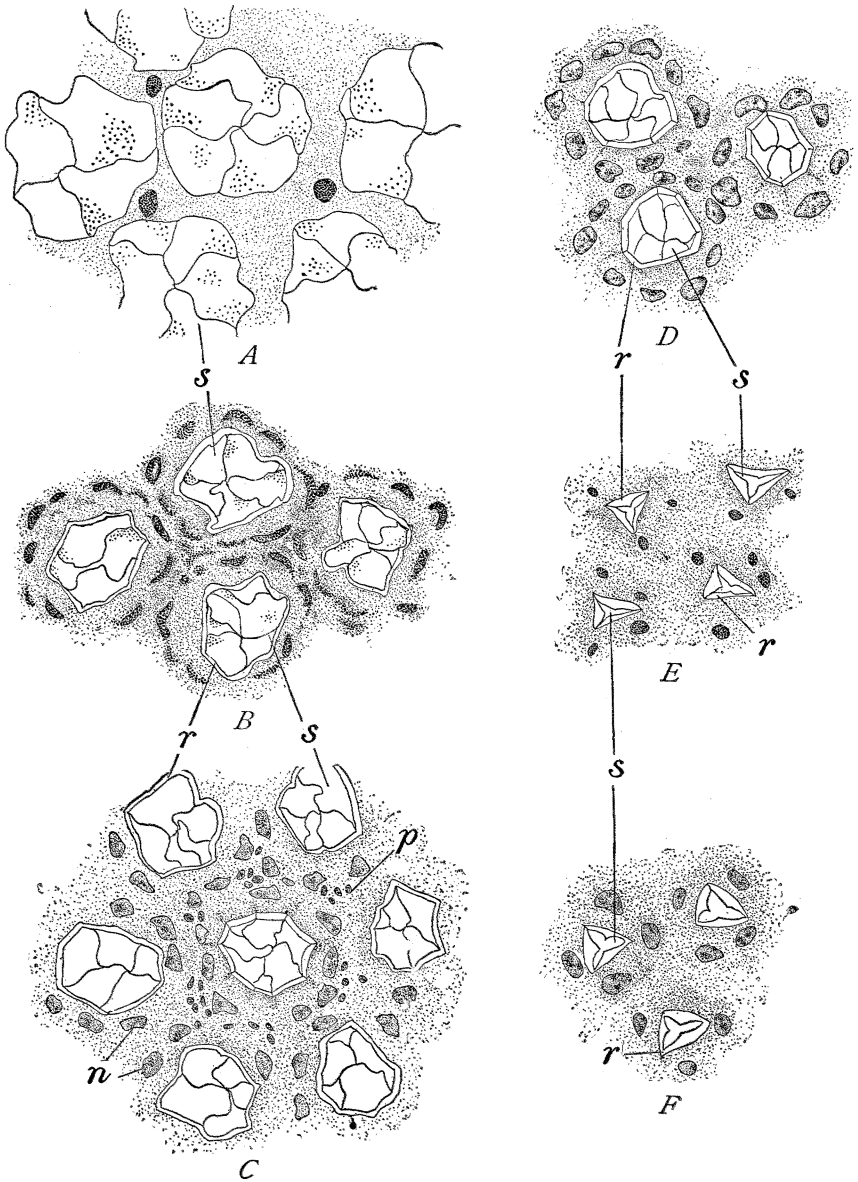

FIG. 2.

early in their existence, thus proving their cell nature. He also states that in an adult these can be vaguely seen. In no eye did I see an indication of nuclei in the segments of the crystalline body.

Cross-sections show the segments to be arranged in no regular manner. In a complete series of cross-sections one ommatidium was followed, and camera drawings at the high and low level were made of each section.

It was thus possible to trace each segment and find the number of segments and their relative position. In most ommatidia the number counted was ten to eleven, but in one ommatidium I was able to trace twelve. It must be understood that in a single section no more than six to eight appear. This can be seen by referring to Fig. 2.

SUMMARY.

The species described by Grenacher is Scutigera (Cermatia araneoidea); by Adensamer, Scutigera coleoptrata; by myself, Cermatia forceps.

The latter is the only American Scutigera.

The differences in the accounts are probably to be explained in part by the fact that the individuals studied were of different species.

(1) The number of ommatidia in each eye of Scutigera forceps is about two hundred. In Cermatia araneoidea (Grenacher) the number is given as one hundred.

(2) The crystalline body was found to be made up of ten to twelve segments, instead of six to nine. No nuclei were observed in these segments.

Each ommatidium is made up of the following cells:

(3) Elongated pigment cells surrounding each ommatidium, sixteen to eighteen in number (p, Fig. 1 *A*).

(4) An outer tier of pigment cells, embracing the distal portion of the crystalline cone, ten to twelve in number (t_1, Fig. 1 *A*).

(5) A middle tier of cells of ten to twelve (t_2, Fig. 1 *A*).

(6) An inner tier of cells situated at the proximal end of the

ommatidium, touching with their proximal ends the basal membrane. In the inner tier there are from three to four cells (t_3, Fig. 1 *A*).

The cells of (5) and (6) secrete, upon their inner surfaces, rhabdoms, and from the outer side send out a process constituting the nerve fibers.

These nerve fibers were mentioned by Adensamer, but his figures failed to show the direct connection between the fibers and the cells of the middle and inner tiers.

In macerated preparations I have been able to show this beyond doubt (Fig. 1 *C*, *D*), and in the ommatidium, before it has been separated into its component parts, have observed the passage of these fibers through the basal membrane.

The expanded proximal portions of the elongated pigment cells (Fig. 1 *B*, *p*) form the layer of pigment spoken of by Adensamer, as found on the basal membrane.

(7) Supplementary cells, four in number, are found at the same level as the cells of the inner tier. They are entirely different, and thus easily distinguished from the cells of the inner tier (*a*, Fig. 1 *D*).

(8) As shown in Fig. 2 *A* certain large nuclei were found in cross-sections at the distal part of the ommatidium. They are found only in the space between three ommatidia. They were not observed, nor the cells to which they belong, in maceration preparations.

BRYN MAWR COLLEGE, April, 1900.

REFERENCES.

'80 GRENACHER. Ueber die Augen einiger Myriapoden. *Arch. f. mikr. Anat.* 1880.

'93 ADENSAMER. Zur Kenntnis der Anatomie und Histologie von Scutigera coleoptrata. *Verh. d. Bot. Ges. Wien.* Bd. xliii.

'96 ROSENSTADT. Zur morphologischen Beurtheilung der Augen von Scutigera. *Zool. Anzeiger.* Jahrg. xix. 1896.